REVIEW

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Since the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, climate change has been recognized as a shared global challenge that requires urgent attention. Many actions have been taken to mitigate the primary cause of the problem—carbon dioxide emission—at local, national, and global levels, and amongst such measures, the expansion of renewable energy is being greatly supported.[1] In fact, over a hundred and fifty countries around the world have adopted renewable energy targets in the decades to ensure a certain amount of energy coming from renewable resources.[2] Consequently, renewable power generation, especially from wind and solar resources, has significantly grown worldwide in recent years. Wind power generation had increased much more faster than solar power generation until early 2010. However, solar technologies and solar resources soon exceeded the popularity of wind power within the global community. The fact that solar photovoltaic (PV) can generate electricity in a small scale at low cost has appealed to many. While wind turbines are often built in remote areas, far away from urban regions where electricity consumption is highest solar PV can be deployed in commercial and residential buildings; in this way,

1 IRENA, OECD/IEA, and REN 21, Renewable Energy Policies in a Time of Transition(Abu Dhabi, 2018), 20.
2 IRENA, Renewable Energy Target Setting (Abu Dhabi, 2015), 9.

electricity from solar resources can be more efficiently distributed in urban areas.[3] This led to the rapid expansion of the solar energy market across the world, as well as an increase in the number of researches conducted on the potential of solar energy. A considerably amount of the researches on solar energy have addressed the advantages of solar resource and its impact on the climate change issue. However, there are only a few works on how climate change will affect solar energy, although it is one of the most climate-dependent types of renewable energy alongside with wind energy. Therefore, in the article "The UK solar energy resource and the impact of climate change," Dougal Burnett, Edward Barbour, and Gareth P. Harrison—prominent climate change and energy scholars—investigated the impact of climate change on the solar energy performance in the United Kingdom (UK) and provided important insights to official actors in the solar energy sector to adapt to climate change.[4]

Summary

Burnett et al. started the paper with a brief introduction to the renewable energy trend in the UK. Unlike most of its neighboring countries dominated by solar energy, the UK has benefited more from wind resources as a result of its cool and cloudy climate. Even so, in order to reach its renewable energy target of producing fifteen percent of total energy consumption from renewable sources by 2020,[5] the UK has recently turned to solar energy as well. More well developed than other renewable energy technologies, solar energy has become more affordable and accessible thanks to the government support, and it is now the second most preferred renewable energy source for the UK government. Solar PV converts global solar irradiance into electricity, and the amount of converted irradiance depends on the angle of the sun, the weather, and, most importantly, cloud cover. Human activities attributed to climate change also caused an increase in atmospheric aerosols, providing a greater amount of cloud condensation nuclei that affect cloud cover characteristics.[6] Burnett, thus, argued that climate change affects cloud cover characteristic, consequently affecting the performance of solar energy[7]directly. Previous studies on China and the United States showed different results in the impact of

3 "Advantages and Challenges of Wind Energy," US Department of Energy Office of Energy Efficiency & Renewable Energy, accessed September 10, 2018, https://wwwenergy.gov/eere/wind/advantages-and-challenges-wind-energy.
4 Dougal Burnett, Edward Barbour, and Gareth P. Harrison, "The UK Solar Energy Resource and the Impactof Climate Change," Renewable Energy 71 (2014): 333 343, doi:10.1016/j.renene.2014.05.034.
5 UK Department of Energy & Climate Change, UK Renewable Energy Roadmap (London: Department of Energy & Climate Change, 2011), 5-6.
6 Burnett et al., "The UK Solar Energy Resource and the Impact of Climate Change," 333. RenewableEnergy 71 (2014): 333, doi:10.1016/j.renene.2014.05.034
7 Ibid.

climate change on solar power. There could be a decrease or increase in solar power, depending on the region and type of solar technology being studied. China and the United States both have a relatively mature solar energy market as well as a greater number of solar system installments. On the other hand, solar energy was starting to grow in the UK when the research was conducted. There is a lack of related works on the UK solar resource and the impact of climate change on them. As a result, Burnett provided a detailed assessment on the UK solar resource. They then combined the assessment with the output of UKCP09 climate change projection to examine the effect of climate change on the estimated future solar resource, to inform actors, such as policy makers, developers and officials, for future evaluation on solar energy.[8]

A detailed solar resource assessment of the present climate would ideally be performed using solar irradiance historical measurement for over a period of thirty years. In the UK, however, weather stations usually only have a record of sunshine duration with a long period of historical information. For an accurate UK solar energy baseline resource map, the authors decided to apply Suehrcke conversion method to convert the period from 1961to1990's monthly average daily sunshine duration data to solar irradiance.[9] In the UPCP09 climate change projection, two 30 year future time periods, 2050s (2030-2069) and 2080s (2070-2099), are explored with three climate change scenarios: low, medium, and high greenhouse gas emission.[10] Adjacent regions in UKCP09 with similar solar energy resource characteristics are merged into six UK solar regions—Scotland North, Scotland Mid, Scotland South & N.I., England North, England Mid & Wales, and England South, to understand the impact of climate change on solar technologies and solar energy resource.[11] Probabilistic data from UKCP09 of 2050s medium emission indicates a significant increase of solar irradiance in southwest, as the increase become less significant toward the north of the country. The projections also show an increase in the solar resource in spring, summer and autumn, especially regions located in the southwest. During summer months, nearly all regions across the UK show an increase in solar resource. According to Burnett, Barbour and Harrison, summer months in the southwest even show an increase in solar irradiance of up to 7.9 percent by 2050s, under a medium emission scenario.[12] On the other hand, over winter months, nearly all regions across the UK will have increased cloud cover; thus, they will have a decrease in solar resource. Yet, UKCP09

8 Ibid.
9 Ibid., 334.
10 Ibid., 339.
11 Ibid. 335.
12 Burnett et al., "The UK Solar Energy Resource and the Impact of Climate Change," 341. Renewable Energy 71 (2014): 341, doi:10.1016/j.renene.2014.05.034.

projections show a reduction of solar energy resource with decrease of up to -2.9 percent further north.[13] The result from the projections suggests that most southern part of the UK will get sunnier as there will be an increase in solar irradiance. The region will benefit from increase in solar power, especially during summer.[14] The authors stated that "in the places where the current [solar] resource is the largest (the south and the south west), the resource will see on average a sizeable increase due to climate change."[15] According to the result they got, the authors believe that it is positive news for solar energy developers as well as the actors in the southern part of the UK. Burnett, Barbour and Harrison concluded that solar energy in the UK has a huge potential to be explored due to climate change, but more research is needed to provide more detailed suggestions to policy makers and solar PV developers alike.

Review

Renewable energy plays an important role in the decarbonization of the energy sector. The positive impact of the renewable energy has already been to the public. Articles have been cited by the media and government to promote renewable energy and to encourage the use of renewable energy. A great amount of scholarly articles have explained solar and wind energy technologies and their advantages. However, only a few scholars have considered the impact of climate change on the performance of the renewable energy resources. As a result, the research done by Burnett, Barbour, and Harrison is both interesting and ironic. It is ironic because the main reason for shifting to renewable energy generation in the energy sector in energy sector is to mitigate the climate change issue; yet, climate change directly affects renewable energy resources and their performance. In the UK case, climate change even increases the solar resources and boosts the solar energy industries.

Burnett's choice of methodology is thoughtful in that the results from climate change projections allow decision makers to reach a conclusion more flexibly in the development of the UK's solar energy sector. UKCP09 projection is the most advanced climate change scenario in the UK. Through it, users are able to know possible climate condition based on the past and current levels of greenhouse gas emission. Most importantly, the UKCP09 climate projections are probabilistic, so they provide a range of change and assign a probability to the range.[16] The probabilistic data resulted from the UKCP09 allows the actors to make a robust decision across the range when designing solar energy related

13 Ibid., 341-342.
14 Ibid.
15 Ibid.
16 UK Climate Projections, "An Introduction to the UK Climate Projections," last modified July 25, 2013, video, , video, https://www.youtube.com/watch?v=wwWBBGvExc8

programs, rather than making decisions for a targeted number. The result, therefore, allows the authors to inform policy makers, government officials and PV investors alike on the future of solar energy resources. Although the study done by Burnett et al. provides a new aspect of the renewable energy and climate change, further research will be necessary to predict the direction of solar resource in UK. The authors argued, "human activity is causing an increase in atmospheric particulates. Global solar irradiance levels depend on the cloud cover characteristics and therefore will change due to climate."[17] However, atmospheric particulates from human activity also directly affect the performance of solar energy, according to several recent studies. For example, Li Xiaoyuan et al, in "Reduction of Solar Photovoltaic Resources Due to Air Pollution in China," found that aerosol pollution over China reduces solar radiation reached at the surface, which led to reduction in solar resource.[18] The authors concluded that clouds generally have a large influence on solar irradiance; however, when the air pollution reaches its peak, aerosol can be as significant as clouds on solar resource.[19] Moreover, Professor Bergin at Duke University found that airborne particles reduce energy output by more than 25 percent in certain parts of the world.[20] Extreme weather resulted from climate change, such as record breaking hot weather, increases the demand in electricity use every year. Although solar and wind energy technologies are becoming more affordable and accessible, the two resources are some of the most climate-dependent amongst renewable resources. Energy generation from wind and solar power will not be enough to provide electricity to the public; therefore, countries, including the UK, will not be able to give up energy generation from fossil fuel, which might lead to constant release of chemical gases. Consequently, the direct influence of particulates cannot be ignored, and should be included into further research. Also, there are events which the authors were not able to predict which might have influence on the solar resource in the UK such as Brexit. The electricity network in the UK is connected to the system in France, the Netherlands, and Ireland through cable called interconnectors and the UK uses these interconnectors to import or export electricity.[21] If the future solar irradiance increase like the authors suggested in the article, the UK would benefit through energy co-operation with

17 Burnett et al., "The UK Solar Energy Resource and the Impact of Climate Change," Renewable Energy 71 (2014): 333-334.

18 Xiaoyuan Li et al., "Reduction of Solar Photovoltaic Resources Due To Air Pollution in China," Proceedingsof the National Academy of Sciences 114, no. 45 (2017): 11867-11872, doi:10.1073/pnas.1711462114.

19 Proceedings Of The National Academy Of Sciences 114, no. 45 (2017): 11867-11872, doi:10.1073 pnas.1711462114

20 Ken Kingery, "Air Pollution Casts Shadow Over Solar Energy Production," Duke Pratt School of Engineering, last modified 2017, https://pratt.duke.edu/about/news/solar-pollution

21 "Electricity Generation | Energy UK," Energy-Uk.Org.Uk, last modified 2018, https://www.energy-uk.org.uk/energy-industry/electricity-generation.html

neighboring countries and steadily transform its energy mix toward renewable resources. However, the Brexit will bring uncertainty to the development of solar resource in the UK. It might hinder any co-operation with neighboring countries. Furthermore, if any EU countries do not want to connect their system with the UK, the excess solar energy generated during summer will go to waste, and the UK might have to face the same struggles in distributing electricity like many countries in Asia. Although further research needs to be done, Burnett, Barbour and Harrison provide a new direction for other research to explore climate change and renewable energy.